Note on an Apparent Violation of the Law of Regular Progressive Debituminisation of the American Coal Beds Coming East.

By J. P. Lesley.

(*Read before the American Philosophical Society, June,* 1871.)

In the course of a Geological survey of certain lands in Somerset County, Pennsylvania, it appeared that the beds of coal existing at Ursina held much less volatile matter than was expected. The gas coals of Westmoreland County, which come east as far as Connellsville, only thirty miles west of Ursina (see accompanying map), hold between 30 and 40 per cent. of volatile matters. Three analyses show the Ursina coals to have but 17 per cent., while a fourth gives 22 per cent. This puts the Somerset County coals into the *semi-bituminous* class. Yet the specimens were taken from gangways, a good many years old, and several hundred feet from the outcrop, under high hill cover, at a point on the *western* border of the First Bituminous Coal Basin of Pennsylvania, near the Maryland and Virginia State line. More properly we should say that the Ursina coals lie in the second synclinal of the First Basin. For the Negro Mountain Anticlinal comes up from Virginia and splits the First Basin into two in Pennsylvania. The mountain dies down at Castleman's River; but the anticlinal axis runs on northward. The First Basin is similarly split into two, east of Johnstown, by the Viaduct Anticlinal, which may or may not be an actual prolongation of that of Negro Mountain.

To make the situation understood, the following extracts from my report to the owners of the property will suffice. The accompanying map shows the Backbone of the Alleghany passing by Altoona. This is the eastern edge of the First Bituminous Coal Basin. The two long parallel mountains between Ursina and Connellsville enclose the Second Bituminous Coal Basin of Pennsylvania. The Third, Fourth, and Fifth lie west of it, and the Sixth occupies the northwest corner of the map; no mountains separating the last four.

Figs. 1 and 2 will suffice to show the topographical character of the country, and how the areas of the almost horizontal coal beds have been cut out into patterns, as if with a jig-saw, leaving outcrop edges around all the hillsides, at which gangways enter, and from the mouths of these shutes depend.

Figs. 3 and 4 give vertical sections of the coal measures made with Becker's Barometer; and Figs. 5 and 6 show longitudinal Vertical sections of the hills.

Special surveys like this have more than a commercial value: they reveal, sometimes very unexpectedly, new truths for men of science. It is an advantage to have them placed on record for common use. Too many of the collected facts of science are annually lost for want of publication.

The property surveyed in this instance, lies in my old tramping and camping ground of 1840, during the fifth year of the State Geological

Survey. The report which Mr. James T. Hodge and myself made to Mr. H. D. Rogers, Chief of the Survey, may be found recorded in the Fifth Annual Report (1841), pages 89–92, which I will here recapitulate in the *descending* order of the beds, for convenience of comparison.

The Pittsburgh bed, I, has been eroded from the whole country between the Alleghany Mountain and Chestnut Ridge (at Connellsville and Blairsville) except two hill tops; one, near Salisbury, and the other near Ligonier. It is possible also that a third exception may be discovered in the high hill country south of Johnstown, where a conspicuous bench runs along the hilltops for several miles.

Limestone, 20 feet below I, 6 feet thick in the Ligonier Basin.

Coal bed H, 50 feet below I, 3 feet thick in the Ligonier Basin; 1 foot thick in the Salisbury Basin.

Coal bed G, 100 feet below H, 1½ feet thick in the Salisbury Basin; encircles the highest hilltops in the Ursina Basin with a conspicuous bench. Fort Hill is not quite high enough to have it.

Red Shales between G and F.

Coal bed F, 90 feet below G; generally small; but 4 feet thick in the Salisbury Basin. It forms the high terrace of the Fort Hill.

Mahoning Sandrock.

Coal bed E, "Upper Freeport," 50 feet below F; 2 feet thick, on 2 feet of *Limestone* (over it Shales with *ore-balls*) in Ursina Basin; 3 feet thick, on 5 feet of *Limestone* in the Salisbnry Basin.

Coal bed D, "Lower Freeport," 60 feet below E, 6 feet thick in Ursina Basin; 4 feet, further north; over 10 feet of Sandstone with *ore balls,* in two beds, 7 feet asunder, 11 inches in all. This ore ball horison is very extensive north and south of the River.

Coal bed C, 20 feet below D, 2½ to 4 feet thick.

Coal bed B, 30 feet below C on Cox's Creek, 40 on Laurel Hill Creek (N. Fork), and 60 at Confluence; 4 feet thick over 8 feet of *Limestone* on the river; 1½ feet thick over 4 feet of *Limestone* on the North Fork. Twenty feet above B lie 15 feet of Shales, etc., containing *ore balls,* on Spring Run, below Pinkerton's Bend of the river.

Coal bed, 22 feet below Limestone, on west bank of Castleman's river, ¼ mile above Zook's run ford, and on North Fork at old salt boring; carries 5 feet of Shale containing 1 foot of *ore balls.*

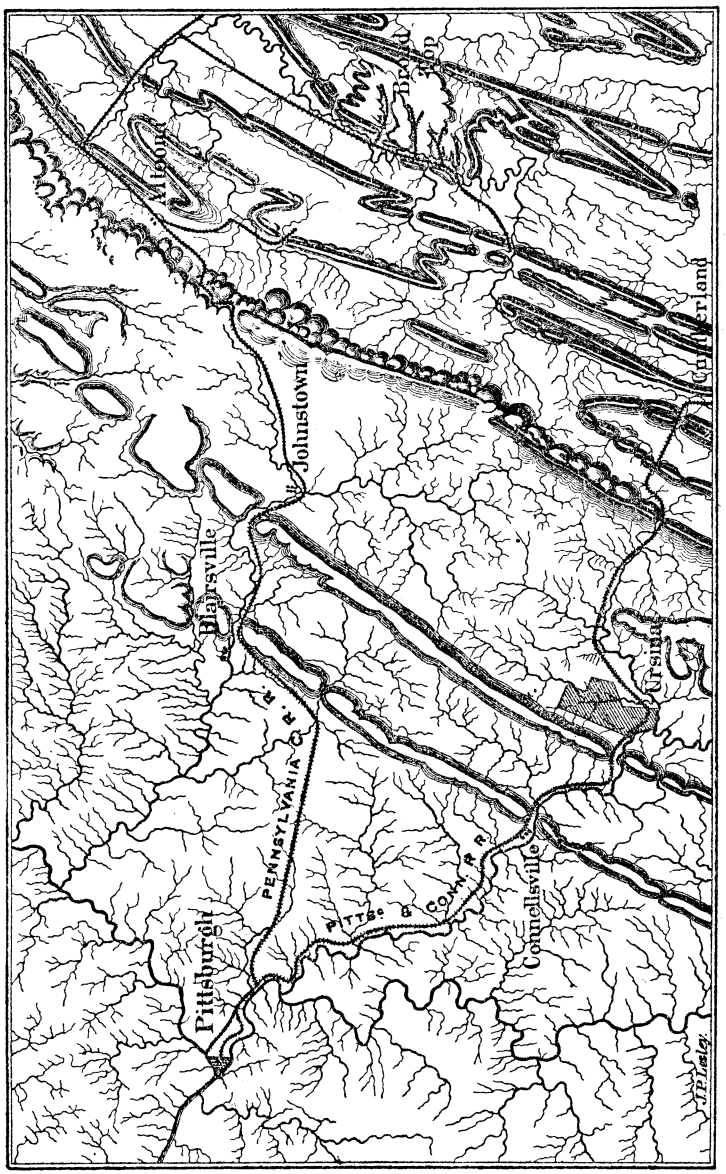
Coal bed A, 70 feet below B; 22 inches thick, at Shroff's Bridge over Castleman's river.

Conglomerate; 30 feet below A; the interval being massive Sandstone.

Such was the general scheme of the Coal measures made out during the old survey, and, however subsequently modified, it has been of incalculable value in all subsequent special, and private investigations. It was a very successful attempt to reduce to system the heterogeneous mass of details collected from all parts of the Bituminous Coal Region of western Pennsylvania outside, or to the east, of the Monongahela River Upper Coal Beds, and of the Alleghany River Lower Coal Beds. It was

A MAP

Showing the Geographical Relations of the Pittsburgh and Baltimore C. C. and I. Co.'s Lands to the surrounding county.



by the collation of these three generalizations, that the first knowledge of the true order of the American Coal Measures was obtained, a starting point and a basis for all the Western Surveys.

It was merely a sketch, however; done hastily, in a single season, and with most inadequate means at our command. In pecuniary power the party fell so low that one of our camps on the North Fork could not be moved, because the whole party could not raise, amongst them all, 37½ cents to pay a farmer's bill for potatoes. A messenger was dispatched to Hanna's at the Turkey-foot, now Confluence, with a faint hope of receiving from the Chief in Philadelphia a remittance. Happily a letter was lying in the Post office which relieved our embarrassments.

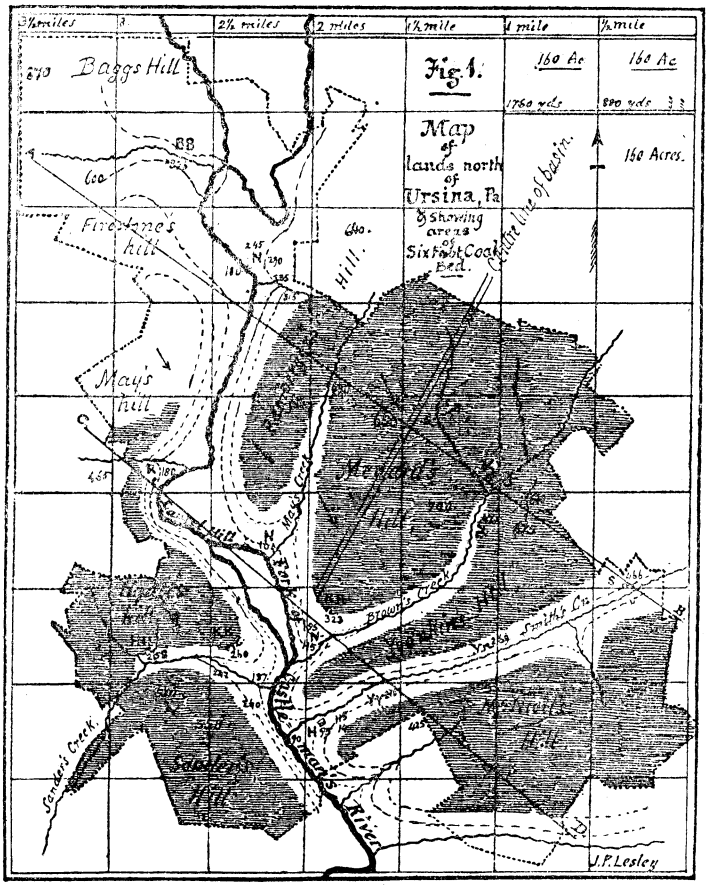
Every subsequent private survey has revealed both the general accuracy and the special inaccuracies of the summary statement of the Fifth Annual Report; and there is work for competent local geologists for a long time to come, tracing the principal members of the column, observing their variations, intercalating the more insignificant deposits, and discovering their sudden, and local, and valuable expansions. We know but little yet of the true nature of the genetic relationships of coal, carbonate of lime, and carbonate of iron. But we know that they hold some curiously fixed relationships of the highest economical importance. Every special survey, therefore, should be published, in the hope of taking another step towards a complete understanding of that subject.

It is with this view that I append a special description of a property recently surveyed, stretching for five miles along the North Fork of the Youghiogheny. The North Fork is the Laurel Hill Creek of the Fifth Annual Report. Its mouth and that of Castleman's river makes the Turkey Foot at Confluence. Ursina is a new village one mile up the Fork. The new Baltimore and Pittsburgh Railway is constructed up the south side of the Fork past Ursina, where its grade is 90 feet above water level. It then passes (by a tunnel) through the hills, and continues its course eastward up the North bank of Castleman's River. Ursina is 86 miles by railroad from Pittsburgh, and 243 from Baltimore. There are 6436 acres in this property, and its greatest width of two miles carries it across the centre of the Coal Basin so as to include both dips; which, however, are very gentle, nowhere exceeding 5° and seldom as high as 1°. There is also a gentle lowering of the central belt or axis of the basin southwestward towards the Turkey foot, which has determined its strikingly romantic topography. The hills of nearly horizontal coal measures are 300 to 400 feet high, and the coal beds, etc., pass through them from valley to valley cropping out in nearly horizontal lines along their sides and around their ends. Easier conditions for mining cannot be imagined. And it is in a country quite destitute of faults.

The coal beds belong to the upper part of the Lower Coal System.

The Six Foot Coal Bed outcrops on the hill-side, over the town of Ursina, at an elevation of about 200 feet above the water. Its outcrop keeps at about this height along the east flank of the Ridge (Minder's and Sander's hill) for two miles, up the west bank of the North Fork. It crops out on both sides of Minder's creek, as high up as the forks, where it gets under the water of the run, which descends rapidly.

Fig. 1.—A MAP SHOWING THE AREAS OCCUPIED BY THE SIX FOOT COAL BED IN THE HILLS NORTH OF URSINA.



In the northern part of the property it outcrops on both sides of the

North Fork, at the same elevation of about 200 feet above water-level, for a distance of two and a half ($2\frac{1}{2}$) miles ;

—Along both sides of Smith's creek, for $1\frac{3}{4}$ miles :

—Along both sides of Brown's creek, for $1\frac{1}{4}$ miles :

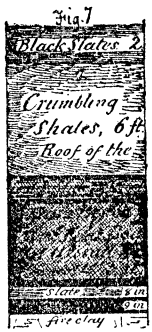
—Along both sides of May's creek, for $\frac{3}{4}$ mile :

—Along both sides of Sander's creek, for $\frac{1}{2}$ mile :

So that the outcrop of this bed has a run of over ten (10) miles.

In this Northern part of the property it lies also in the best manner possible for mining ; falling gently in all directions towards a central point, or mining location, between the mouths of Smith's and Brown's creeks. The arrows on the map (fig. 1) show the direction of the fall of the coal. The two parallel lines (from R R northeastward) show the central axis of the basin, or deepest part of the coal bed, falling towards S. 30° ± W.

Down this central axis the coal bed falls at the rate of less than 1° ; or, between 60 and 70 feet in the mile. The *fall* from the Krieger bank to the Rose bank, W. S. W. is 150 feet in a little less than a mile. The *rise* from the Rose bank to the crop, up May's creek, northward, is 120 feet in a little over a mile.



The following openings on this Six Foot Bed have been worked for several years :—

The Krieger Bank one mile up Brown's creek, south side ; 9 feet above the water-bed ; runs in 109 yards, E. 10° S. ; coal mined from several small breasts, not many tons altogether. It is represented in Fig. 7.

Top Rocks : Black Slate	2 feet.
Crumbly Shale	6 feet.
Top coal, with three half inch slates	1 foot.
Main coal, solid bench, with occasional wedges of drab clay	5 feet.
Slate not taken up	8 inches.
Bottom coal, bench not taken up	9 inches.

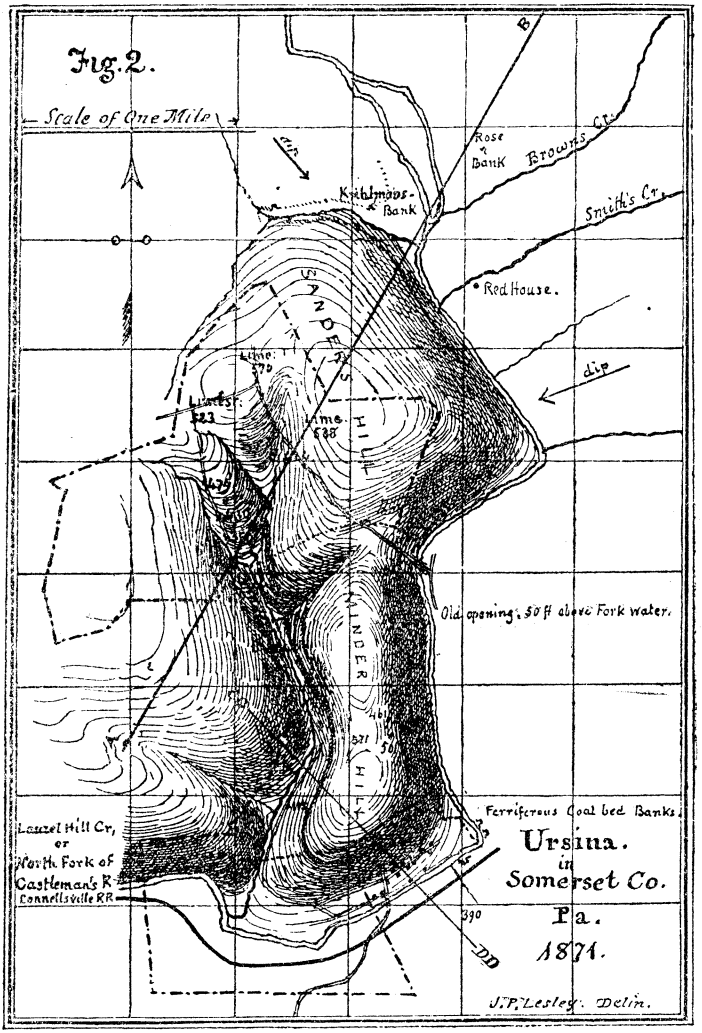
The following analysis by Mr. Persifor Frazer, Jun., shows a superior percentage of solid carbon with a minimum of ash, sulphur and water :—

Carbon (coke)	79.25 (or $\frac{4}{5}$ of the whole.)
Volatile substances	17.17 (It is therefore not a gas coal.)
Ash	3.11 (an extraordinarily pure coal.)
Sulphur	0.47
Water	0.55
Total	100.55 : in which the sulphur has been considered exclusively a constituent of the Ash.

The specimen (No. 1) was obtained from the Krieger bank, some distance back in the gangway, and midway of the bed, between the roof and floor, and may be considered a fair specimen of what the bed will do when mined on a large scale.

A MAP showing the Topographical Character of the Southern part of the Lands of the Pittsburg and Baltimore Coal, Coke and Iron Company.

(*Reduced by Photolithography.*)



The ash is remarkably small—the coke very great (nearly $\frac{4}{5}$ths of the whole); and the gas no higher than in Broad Top Coal; water and sulphur about half of one per cent. The small percentage of water in these coals is remarkable.

The coal is friable and comes out much crumbled, and will not bear transportation, but makes a very nice grey even coke. The crumbling shale roof will call for very careful mining and abundant timbering to keep the mine in good order. But while timber is abundant in the district, longwall mining will let the roof fall behind and afford plenty of slate stuff for gobbing up, where needful.

The Rose Bank, opposite the mouth of Brown's creek, facing south, 220 feet above water; shows six feet face of coal, very good, except that there are a few thin layers of slate in the top bench of 12 inches, as before; a coal of 8 inches is said to underlie the bed, as before; roof, again, crumbly shale; coal very friable; it is roughly coked in the open air in front of the mine and makes good coke.

The Kuhlman Bank is opposite to the Rose, on the west side of the valley; and an old mine is $\frac{3}{4}$ mile further west on the same outcrop, and at the same level, 25 feet above the bed of Sander's run. Both are fallen in. The people say that the bed exhibited the same character as on Brown's creek.

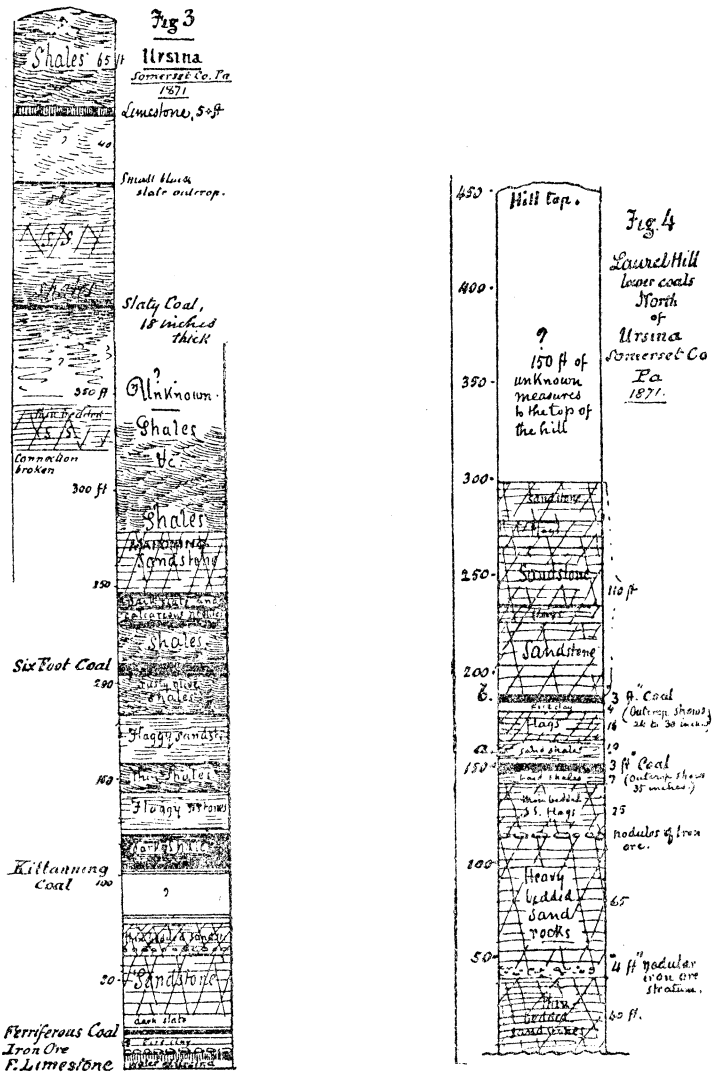
The bed has not been fully opened at the southern end of the property, but I see no reason why it should differ in quality or thickness here from where it is opened further up the North Fork, since it runs with remarkable regularity of thickness and character from the Krieger bank (up Brown's creek), to the Kuhlman bank and the old opening on Sander's creek, a distance of two miles.

Geologically, this bed is the continuation southward, into Maryland, of one of the Freeport beds of the Alleghany River System, having a wide extension through western Pennsylvania, and usually furnishing the best of coal. For want of special instrumental surveys in the country south of the Conemaugh, it is not now possible to assert positively to which of these two Alleghany River Coal beds the Six-foot coal, in southern Somerset county, answers best. Our best guide, the great lime rock which underlies the upper of these beds, thins out as it approaches the Allegheny Mountain and the Maryland line. But as we have a dark Shale, with limestone nodules, overlying our Six-foot coal bed, and beneath what is probably the Mahoning Sandrock, in the same position as that occupied by the upper of the two Allegheny River beds, the Six-foot coal would seem to be the lower.

If a colliery were established at the mouth of Brown's creek, and three incline planes ascended the ends of Younkin's hill, Menard's hill, and Hyatt's hill, then from the tops of these three planes, three main entries would have three unbroken coal fields straight before them, with a rising coal; in Youngkin's hill rising eastward; in Menard's hill rising northeastward, north northeastward and northward; and in Hyatt's hill rising west northwestward. The point is a rare one for large mining operations.

VERTICAL SECTIONS OF THE COAL MEASURES NEAR URSINA, SOMERSET COUNTY, PENNSYLVANIA, BY FRANKLIN PLATT, JR.

(*Reduced by Photolithography.*)



The gangway entering Menard's hill (at or near the present Rose bank), would command an unbroken area of one and three quarter square miles

of the Six-foot bed, containing the *gross* amount of.....10,500,000 tons,
and by tresseling May's and Brown's creeks at their upper parts where the bed is near their water level, mining might be carried forward into the Ramsbérger and Krieger area, and add..... 1,500,000 tons,
making in all.....12,000,000 tons,
commanded by this gangway.

The gangway at the end of Hyatt's hill, would command 2,250,000 tons,

The gangway at the end of Youngkin's hill would command..... 1,500,000 tons.

The amount of coal to be reached in the easiest possible way, and concentrated at one coal dêpot at the mouth of Brown's creek, is therefore evidently larger than the necessities of the largest collieries for an entire generation.

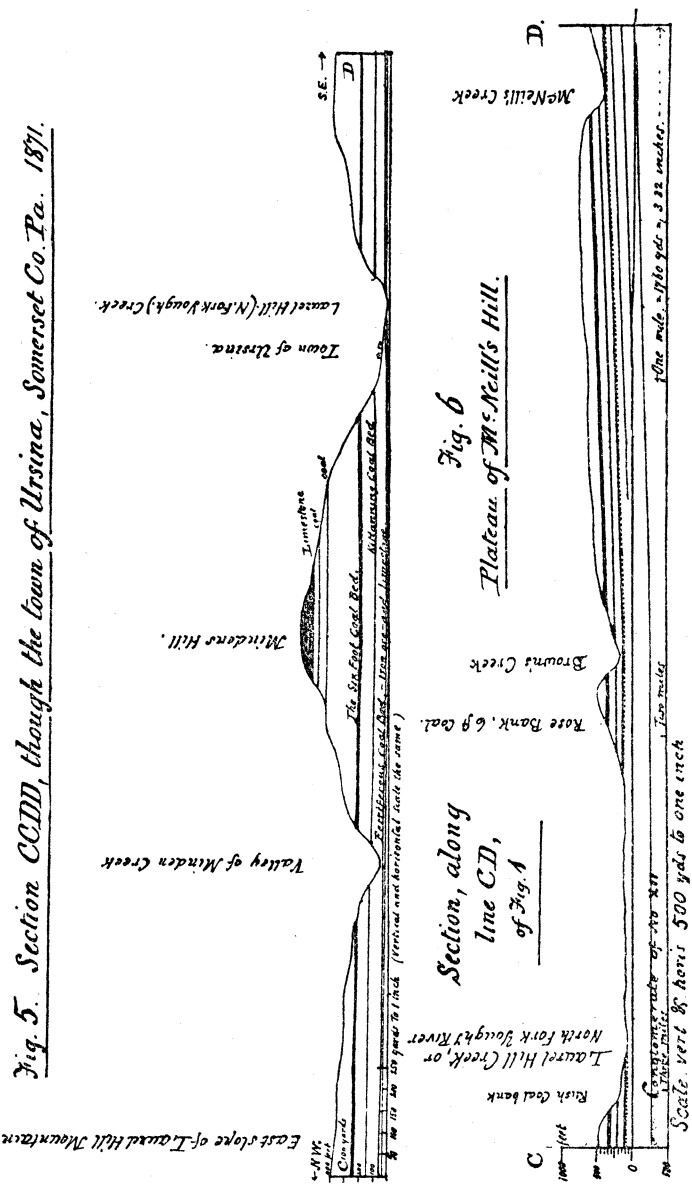
When the main gangways become inconveniently long, their air-ways along the outcrop will afford the most convenient outlets for slack and waste; and new gangways can enter any where, because the drainage of the mine will be perfect.

A fine colliery can also be established at the forks of Minder's Creek, a mile and a half above its junction with the North fork. Here the Six Foot bed strikes the water level of the run; gangways may be driven in horizontally west, northwest, north, northeast, and east, commanding an entire square mile of coal lands, or six million tons of coal. The tramroad for such a colliery will be, say $1\frac{1}{4}$ miles long, with a grade of 10, or between 90 and 100 feet to the mile, which may be lessened by judicious arrangements. This point has another advantage: it will permit *all* the Sander's Hill coal to come out, down grade. I never saw a more beautiful situation for a first class colliery on bituminous coal. Nor do I know of a better coal on which to establish a great coke trade.

The Turkey-foot is likely to become a second Johnstown, in the way of iron works, occupying precisely the same position, geographical and geological, upon the Baltimore and Pittsburgh through railway line, which Johnstown occupies on the Philadelphia and Pittsburg through railway line, as the map on page 3 will show; and just as Blairsville and Connellsville occupy precisely analogous situations, geological and geographical, to each other. At Ursina, the coal beds, iron ores, limestones occur in the hills in the same way that they do at Johnstown; the hills are of the same shape; and the minerals lie at the same angles with the horizon, and at similar heights above water level. At both places the Pittsburgh and Green county coal beds are absent, swept from the tops of the highest hills. At both places the blue carbonate iron ore of No. XI. underlies the conglomerate on the flank of the mountain near the top. And as Johnstown gets brown hematite ores from the limestone valleys of the Juniata, and fossil ore from Frankstown, and Lake Superior ore from Cleveland, to mix with the ores under the coal beds in its hills, so Ursina can get fossil ore and brown hematite from

HORIZONTAL SECTIONS OF THE COAL MEASURES NEAR URSINA, SOMERSET COUNTY, PA., BY FRANKLIN PLATT, JR.

(*Reduced by Photolithography.*)



Cumberland and other points on the Potomac, and the same Lake Superior ores via Pittsburgh, to mix with same iron ores which lie in the hillsides of Castleman's river and Laurel Hill Creek.

Two other coal beds range through the property. The Kittanning bed 100 feet lower down the hillsides than the six foot; and the Ferriferous bed, nearly at water level. Two other small seams of coal exist in the hill tops, belonging to the middle or upper part of the Barren Measures, under the Pittsburgh Coal Bed.

The Kittanning Bed averages 2½ feet, and is best opened at Ursina. This bed outcrops all around the hill sides, north of Ursina; but goes beneath water level of Minder's Creek, two-thirds of a mile up from its mouth. It outcrops all the way up the North fork.

A thirty inch coal bed is opened at the Rush Bank, 1⅓ miles above the mouth of Brown's Creek, (fig. 1), 25 feet above the water of the North fork (Laurel Hill Creek). This bed underlies the Six Foot about 100 feet, and is the Kittanning coal bed. It shows 30 inches of good hard coal, with 15 inches over it of slate mixed with thin coal seams, and a roof of soft shales, requiring careful timbering. Its floor is a massive sandrock, without a particle of intervening fireclay. The bed has only been stripped at its outcrop; but yields cubical masses of very firm coal.

This is the usual Cannel and Block Coal bed of the country.

The Ferriferous Bed, (so called, not because it carries, itself, any iron, but because it always comes into the measures just above a limestone which is called ferriferous because it carries on its upper surface the great iron ore deposite of north west Pennsylvania, especially in Clarion, Venango and Armstrong Counties), averages 2½ feet, and lies just above water level at Ursina. It sinks beneath water level going west, down the fork. It has been opened, also on the property, at the mouth of May's Creek, and at the mouth of Brown's Creek, on both banks of the creek. On the north bank 25 inches of coal is visible, with a 3 inch slate parting. On the south bank 20 inches of coal, 3 inches slate, 5 inches of coal; roof, 2 feet of iron-stained shales supporting 30 or 40 feet of sandstone; floor, hard slate; under this, a thick bed of fire-clay, containing nodules of iron ore; under this, limestone, said to be 18 inches thick.

The bed is not thick, but its quality of coal is good; the mineral coming out in solid blocks, and apparently adapted for the iron manufacture. Mr. Frazer has made two analyses of it, with the following results:

	No. 1.	No. 2.	Mean.
Volatile matters and water	17.12	17.13	17.125
Water alone	0.30		
Fixed carbon	68.20	68 87	68.535
Ashes	14.68	14.00	14.34

Another specimen taken from the Widow Croll's bank, near the mouth of Brown's Creek, shows the same character of this lower coal, above the limestone; equally free from water and sulphur as the Six Foot bed; more gas (equal to Alleghany Mountain Coal in this particular); a large quantity of ash; and 3-5ths of it coke.

Water	0.55
Volatile substances (Gas)	21.90
Carbon (Coke)	60.98
Sulphur (in ash)	0.62
Ash	15.95

The Ferriferous coal is opened also at the head of Smith's Creek, on both banks of the creek. On the south side a pile of half burned lime, shows how strongly ferruginous the limestone stratum is. On the north side, the outcrop exposed by digging, shows two feet of coal, the upper foot slaty; 1 foot of clay, with nodules of ore, in the roof; over this again 1 foot of sandstone; then one foot of dark slate; then a heavy sandstone. The floor is a thick bed of fireclay, the upper 3 or 4 feet being closely filled with nodules of iron ore.

At the base of the Ramsberger Hill and on Bogg's Creek, at the north end of the property, this coal, and another bed 30 feet below it, (see section fig. 4), apparently 24 to 36 inches thick each, and mixed with slate, occur again, and no lower measures are visible anywhere. The conglomerate at the base of the coal measures is just underneath them; the same which may be seen in the gap below Confluence, making a great arch in the mountain.

The fire clay under the ferriferous coal is usually about 4 feet thick.

The Ferriferous Limestone shows about 18 inches thick on the east bank of the North fork, but its general thickness I do not know. It is the same deposit which on the Slippery-rock and Beaver River country furnishes the *soda*-lime for the Pittsburgh works. On Smith's creek the farmers have tried to burn this limestone for use, but failed, and the calcined fragments show that it contains much iron, and may, therefore, make a superior blast furnace flux.

This bed underlies the country about water level, and is very consistent with the character given above. At Ursina it shows the same slate parting near the bottom, and the same underlying beds of fire clay, iron ore and limestone. It will probably play an important part in the future development of the Turkey foot district.

A small (2 inch) layer of nodules of iron ore occurs about 65 feet above water level at Ursina, but it is, of course, worthless at this point.

A small coal bed outcrops 127 feet above the Six Foot bed, over the Krieger bank.

One of the limestones of the upper part of the barren measures comes in, between 475 and 525 feet above water level, near the summit of Minder's Hill, and extends through the hill tops of the property west of the North fork. It is at least 5 feet thick, and ferruginous.

About 100 feet below this limestone is a thin coal vein, very slaty, and good for nothing. There is also a bed of coal-slate 40 feet under this upper limestone.

The analyses given above are important. They oppose the law of *progressive bituminisation westward* of the coal beds.

That both the 6 foot and the 3 foot Ursina beds, situated at the western limit of the 1st Bituminous coal basin, should have only 17 per cent. of volatile matters,—not more than the coals of the Broad Top Region, lying one hundred miles to the east of Ursina,—is truly remarkable. The Broad Top beds are tilted and faulted abundantly. The Somerset County beds are almost perfectly undisturbed. The coal in one gangway showed 22 per cent. of volatile substances. But even this is no greater than the coals of the summit of the Alleghany Mountain, and the coals of the Cumberland Coal Region.

No proper scheme of the *rates* of *debituminisation* to *casting*, and to *disturbance*, can be obtained until all the analyses of each bed in the series of Coal Measures shall be tabulated apart from the rest. We may then expect to learn something also respecting the influence of specific vegetation upon the percentages of coke and gas.

But in the outset one source of error must be guarded against. The specimens of coal from which the foregoing analyses were made, were obtained in the walls of old gangways. It is possible that they had been long enough exposed to the air to lose some of their hydro-carbons by spontaneous evaporation. The rate at which this goes on in coal mined and exposed in heaps, is variously stated by those who have investigated the subject.

Dr. Richters made a recent communication to a German Journal, in which he states his opinion, that the weathering of coal depends upon its ability to absorb oxygen, converting the hydro-carbons into water and carbonic acid. At a heat, say of 375° F, only 5 or 6 per cent. of the carbon accepts oxygen, the rest seems to show little or no disposition to affine with it. The process is apparently dependent upon the per centage of hydrogen. But with coal, cold, or at ordinary temperature, the oxydation is so slow as to be imperceptible, even after exposure for an entire year. He says moisture has no accelerating effect, unless pyrites is present in quantity. Pure coal, heaped up for nine months or a year, unprotected by the weather and not allowed to become heated, is changed no more than it would be in a perfectly dry place.

Herr Grundmann, of Tarnowitz, on the other hand, has recently published elaborate experiments proving the effects of exposure on bituminous coals to be most serious. Coal which he exposed for nine months, lost *fifty per cent.* of its value as fuel. His conclusions excited such doubts, that his experiments were repeated, in connection with Herr Varrentrapp, of Brunswick, who proved, by laboratory experiments, that oxydation took place at common temperatures. Three months sufficed to rob coal, kept uniformly at 140° C. (284° F.) of *all its Carbon*, a heat less than that evolved in coal heaps exposed to the air.

Grundmann proved that the decomposition was the same in the middle of the heap as at the surface, and reached its maximum about the third or fourth week ; that half of the oxygen was absorbed during the first fourteen days ; that a coal poor in oxygen absorbs it most rapidly ; that moisture is an important condition ; that coals making, when freshly mined, a firm, coherent coke of good quality, make, after even only *eleven days'* exposure, either no coherent coke at all, or coherent coke of quite inferior quality. For gas purposes also, the coal is greatly injured.

It is evident that these facts have an important bearing on the value of the analyses given above.